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## THE USE OF THE PRISMATIC COMPASS IN MINE SURVEYING.

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BY E. D. WILEMAN.

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*Mr. President and Fellow Members:*

I shall not attempt anything at all profound in this short paper, but simply relate my experience in the use of a very convenient, but which is in this country a much neglected instrument, the prismatic compass, one of which I have here, and invite all those unacquainted with it to examine it at the end of the session. I had been aware of its merits in the matter of surface detail for several years, but had always hesitated to use it in mine work on account of the necessity of entire dependence on the needle. Last summer when making the survey which I have mapped out here, I had occasion to procure tolerably accurate detail in some rooms where falls of roof made it extremely difficult, if not impossible, to take an ordinary transit, in fact I went through a fall where no means at all could have been devised of using an ordinary transit. I therefore made up my mind to at least experiment with the prismatic and see what it would do, especially as I had the opportunity of making a complete circuit and thus checking its work. I have here a small scale map of the whole mine, and a large sketch of the portion described in this paper. My main traverse branched at 1<sup>st</sup>, at which point a half course butt entry turned to the left, while the face entry continued on down to 2, a short piece of butt starting off at 2', from which a room had been turned both ways, from the room to the left you will notice a room had been turned farther in and from it again another room started, and next to the last an entry was started but it only had one room, at the first appearance the fall at *P* seemed to utterly shut me out of that portion, but after getting the map nearly drawn I saw that I ought to be able to get in through the rooms that turned to the right from the half course entry, I then started with my prismatic, for I had found by previous exploration that the fall at *E* was too high to get over with a transit, I made a complete round as the dotted traverse shows, starting at 37 taking a point as far in the fall as convenient at *P*, returning through another room and closing on 36, you will note how close the closure at 36 is, making it for all

practical purposes perfectly accurate, on platting this I found that the point  $P$  was so close to the other side of the fall that I surely ought to be able to get through it, so with a little search I found a hole that I could just crawl through and projected the short traverse shown from a point near  $2'$  to the point on  $O$ , you will see that they lack considerable of meeting, but I ascribe that to the lack of care in measuring the traverse from  $37$  down to  $O$ , for of course the traverse between  $37$  and  $2'$  by way of  $1R'$  was very carefully taken in all respects, while the following description will show the line from  $37$  to  $O$  was only measured to the nearest foot each time, and very little attention paid to the matter of keeping the tape level.

My manner of procedure was as follows: on starting I set up the instrument roughly as near as I could judge by the eye alone over station  $37$  of the main traverse, then sent my assistant as far ahead as I could conveniently see the lantern when it was set on the floor, I then took an observation on it, reading to quarter degrees, he had taken the front end of the tape with him when he first went, so as soon as I had put the bearing in my note book I pulled up the tape and noted the nearest even foot, he holding the end over the lantern, then if any detail was to be taken between these points we laid the tape down carefully on line and used it as a base line to measure from, but if no detail was desired I picked up the compass as soon as the measurement was made and went ahead, on reaching the front light I set my lantern down in place of the front one which my assistant picked up and went ahead thus repeating the same performance over till it was all done. A little practice will show a person just how to hold the head so that the head lamp shall light up the graduated ring, and the work can be done almost as fast as one person can walk through leisurely, for the first man starts ahead as soon as you reach him, and you will soon be able to set up quick enough to be ready to take notes as soon as he sets his lantern down and it takes but a moment to get the notes, when you are ready to move up again. I would mention that in this particular case I took back as well as foresights in order to be able as far as possible to eliminate any local attraction by reducing and using the magnetic angles, but the results by that method was not good, it brought the closing point north of the main entry, so I platted by simply using the foresights with the result which you see here, showing that for work of a secondary nature it is a very reliable and speedy instrument. In getting through the fall at  $P$  I took it off the tripod and held it in my hand while making the observations, you will thus see that it is possible to use it wherever you can crawl through and see ahead.

SECRETARY HASELTINE: Mr. President, I regret I did not get the forepart of Mr. Wileman's paper from the fact that I was looking over one that has been sent by Mr. Willard. I examined hastily the prismatic compass. For lightness and convenience of handling in mines it is certainly well adapted for that work, and would relieve the engineer of a great deal of burden in carrying a heavy instrument which is subject to a fall. I would like to ask Mr. Wileman if in using the foresights alone whether there would not be liability to great error where he relies upon the magnetic needle for his bearings.

MR. WILEMAN: I would not use it for primary work at all. It is only for secondary work where there are falls, etc., which make it difficult to get to.

SECRETARY HASELTINE: It is only for filling in after the main traverse has been made.

MR. WILEMAN: Yes sir.

SECRETARY HASELTINE: Now could you not use the same instrument by using the backsights and reduce the angle in that way, could you not use it for primary work of any kind.

MR. WILEMAN: You might and get tolerably fair results, but the fault in making the reduction as I did was that it is important to place very little dependence upon it. I took foresights and backsights and reduced them, and it brought me, instead of to this point, 2 entries and a pillar beyond.

SECRETARY HASELTINE: Might not that be some error in calculating the angle and not the instrument.

MR. WILEMAN: It might possibly, but I don't think it was.

SECRETARY HASELTINE: And the fact that it was a new instrument and you were not acquainted with it.

MR. WILEMAN: I would not begin to depend upon it for primary work at all.

SECRETARY HASELTINE: Then its chief use is for filling in the topography of the mine.

MR. WILEMAN: Yes sir, that is all I recommend it for anyway.

SECRETARY HASELTINE: Have you ever used it in more than one instance?

MR. WILEMAN: Yes, I used it in several instances for running into rooms, for it don't matter if the end of a room is in exactly its proper position by a foot or not, but then you get the general appearance and shape of the room for ordinary purposes.

PROF. LORD: I would like to ask what would be the average variation from the truth in running the length of a room in that way?

MR. WILEMAN: I wouldn't expect them to be over a couple of feet.

PROF. LORD: You are safe to count on it at that.

MR. WILEMAN: I should think so from my experience and even closer than that. I think that a magnetic instrument of any description is less of a check than any instrument of absolute measurements, because the same influence that diverted it in one direction would divert it in going back.

SECRETARY HASELTINE: That is only true in cases where your sights are of nearly equal length and your deflections nearly equal in number, and all deflection to the right or left. If you are running one long line and then a dozen short ones to close it probably it would not close. I have frequently noticed in my surveying, I don't know as I know the maximum variation, but I used a railroad compass for a great many years and used the vernier and used the needle as a check, that was done in our veins of coal in which the entries were very crooked, and frequently you would not get a sight long enough to draw your chain the full length in a day. A great many of them would be 25 feet, 30 feet, 50 feet, etc., and I used the needle as a check on it, and I have noticed the difference between the backsight on one station and the foresight on the other to vary as high as  $8^{\circ}$  on the needle. Well now if that distance was long it would throw you a long ways from the correct point on the surface at that place, that is,

if you relied upon the needle alone. Then if your next deflection was in the opposite direction and you got substantially the same in the course of a dozen or twenty stations, you would come pretty nearly to the correct point, but there would be points in that entry where you would be off probably 20 feet. If the entries are approaching a land line in which the royalty changed you would have to survey that as Mr. Wileman has or any instrument in an accurate manner. In the middle of the field for the purpose of delineating the work, I have frequently used my stations that I had along the entry for an initial point and step the length of the room, and it did very well for topography. It would be sufficiently accurate in the interior of the mine for practical purposes, but when it came to the boundaries of land lines it had to be surveyed accurately, and for that work it would seem to be rather doubtful as to whether this instrument would be accurate or not, as we would have to start the instrument where there was iron. Where there was strap iron it would make trouble, and where there was a roof of sand-stone, where there were balls of iron pyrites which are frequently magnetic it would make trouble again.

MR. WILEMAN: I finished a map just before I came down here where I took in succession ten rooms off one entry and had a check measured through off the last breakthrough. I measured six rooms and they came out all right starting on a T iron entry. In connection with the extreme variation I might mention as a curious circumstance that in one of the mines in the Massillon district even on lines of only 30 or 40 feet long I have noticed a difference between the front and back magnetic bearing, a difference as great as  $25^{\circ}$ , when the outside or surface bearings of that same mine would not be between those two extremes as much as  $10^{\circ}$  away from each other on the outside.

SECRETARY HASELTINE: I did not get that last portion of your remark, the difference on the outside.

MR. WILEMAN: The magnetic bearings on the surface of that same line would not be as you would expect, a mean almost between those two extremes of the inside bearings, but would lie outside of those two extremes as much as ten degrees.

SECRETARY HASELTINE: The outside would not be any indication that the bearings on the inside are correct. The inside bearings depend upon the quantity of iron and direction and your position. If you were sitting over a frog you would probably get a greater variation than if sitting in the middle of the track, and the outside bearings, if there are no atmospheric disturbances, would be the true magnetic bearings.

MR. WILEMAN: Yes, but I noticed in that particular mine that the thing occurred even in wooden track entries.

SECRETARY HASELTINE: Then there was iron pyrites in the roof.

MR. WILEMAN: I don't know what caused it, but it runs through the mine there everywhere.

SECRETARY HASELTINE: Wasn't it a rock roof?

MR. WILEMAN: A rock roof so far as I know.

SECRETARY HASELTINE: I always found difficulty in getting a check on the inside of a mine whenever I was working under a rock roof.

THE CHAIR: That slate sometimes above the coal and shale carries more iron than where the rock is.

MR. ROY: It is rare to find iron in rock, but in shales it is quite common.

SECRETARY HASELTINE: I never saw iron balls in the slates. It was always in the roof between the slate and rock.

THE CHAIR: Well, you will find where the roof has no rock at all that it is full of iron balls.

MR. ROY: The mine at Washingtonville, where they make the coke, has a band of iron ore right over it.

SECRETARY HASELTINE: It is non-magnetic. Mineral ridge back band ore is non-magnetic. You could set your instrument in a field and take your bearing and move your instrument right up opposite a pile of that ore containing thousands of tons, and it would have no perceptible effect upon the needle at all.

MR. ROY: How would you account for that?

SECRETARY HASELTINE: I don't know, only that it is non-magnetic either when roasted or when raw. It makes no difference whether the ore has been first roasted or not.

THE CHAIR: Talking about that, why is it, Prof. Lord, that sometimes with an iron ore, for instance take the republic, the best ore that we have and it will not take the magnet, and then you get an iron ore that has only about 15 or 20° and it will take it; why is that?

PROF. LORD: The iron ores are magnetic or not according to the amount of oxygen they contain. The fully oxidized ores like the republic ore, which is a hematite or the red hematites of some of the southern mines, or the hydrated hematites contain all the oxygen the iron is capable of taking up, and such ores are never magnetic in that state when fully oxidized. Now the black band ore you are speaking of contains carbonic acid, and the combinations of iron and carbonic acid are not magnetic. The only iron ores that are magnetic are those that contain intermediate amounts of oxygen between the carbonate ores and the hematites or fully oxidized ores. Now such ores are sometimes found disseminated all through slates and limestones, quartzes and everything else are liable to contain disseminated grains of these intermediate oxides. All such rocks are magnetic.

THE CHAIR: The reason I asked the question, I understand our Secretary here to say that the black band mineral ridge ore is not magnetic. Do I understand you to say the black band ore is non-magnetic?

PROF. LORD: I say black band ore free from these other oxides is not magnetic. Black band is carbonate of iron. Such combination is not magnetic, but if you take out that carbon you will leave it in a magnetic state. When you burn these magnetic ores and it loops badly, it will be magnetic. But when you burn it and the oxygen is driven into it, that compound will not be magnetic. Now in regard to the sulphur compounds, something the same is true of the sulphur compounds. If, as very often is



the case, the quantity of sulphur is intermediate between the amount fully necessary to saturate the mine and half the amount, the sulphur will be magnetic. Such will make the magnetic pyrites. The magnetic quality always comes with imperfect combination, and the fully oxidized ores will not be magnetic.

THE CHAIR: There is a point there I should like to be thoroughly advised upon, because my experience differs so much from what your remarks contain and our secretary. Now I never knew that black band ore in the raw was magnetic, would not touch the magnet at all any more than if sandstone. Now if I have understood the drift of your remarks when the black band ore is well looped it may be magnetic. Now my experience entirely differs from that. The black band ore of Tuscarawas County, which probably is outside of mineral ridge, the only black band ore we have in the raw state is not. Burn it or roast it a little but not loop it hard, don't let it run but merely roast it, then it becomes magnetic. But when you have it looped so that it becomes almost iron, it is not; that is, the part containing 20 or 25 per cent. of iron will take the magnet on the jump, while that which contains 50 or 60 will not touch it.

PROF. LORD: Perhaps we are a little at sea on the question of burning it. The extent of the burning would determine whether the product would be magnetic or not. If you burn the black band ore slightly so that a little oxygen only is put in it, it will be magnetic. If you burn it completely so that the oxygey is carried to it in that amount it will lose its magnetic qualities. In many ores I have seen an intermediate burning is accompanied by more or less looping. By looped ore I meant an ore that had been blacked and run.

THE CHAIR: Well, now that is my experience that when you get to that state it don't take the magnet, but in the intermediate state it does, that is just charred. Put it in the fire until it is merely charred and rub it, get it fine, then it will take the magnet instantly. It acts just I have stated about the republic or any highly ironized ore. I have been surprised at that because the magnet will not take a very rich ore.

PROF. LORD: I know of ores 65 or 70 per cent. that will, but they contain sufficient oxygen.

THE CHAIR: Are there any other questions to ask Mr. Wileman?

MR. ROY: Mr. Chairman, it is the habit of the Institute to always extend a vote of thanks for the reading of a paper. I would rather for my part that that custom was dispensed with, because there is never a paper read but what this is done, and we always have good papers. In order to fulfill the custom for this valuable paper I move a vote of thanks to Mr. Wileman.

The motion being seconded prevailed.

THE CHAIR: I must confess that I don't understand enough about the compass to criticise the instrument. I wish I did, but I have no doubt it is of great value to any one who does understand it, and I have no doubt it is a new departure and that the prismatic compass will be very handy. I would like to ask this question: would that be of any particular use to the mine boss?

MR. WILEMAN: I think a mine boss could make it very useful.

THE CHAIR: Don't you think it would be more in place in that position than any place else?

MR. WILEMAN: I think most any mine boss would make it well worth its cost in use. It would take a very short time to learn to use it.

THE CHAIR: The next paper on the programme is a paper by Mr. Willard of Hanging Rock, O., on the subject "Mining Limestone by Underground instead of Open Quarry Work." That is something new that I think we have never had before us before, because it is a thing that is not often done.

SECRETARY HASELTINE: I wish to say that Mr. Willard enclosed me his paper several days ago, and with it a letter saying that he expected to be here, but for fear of an accident he would forward the paper so that we would have it. I very much regret that Mr. Willard is not here to participate in the discussion of the paper.

At this point the Secretary read Mr. Willard's paper.